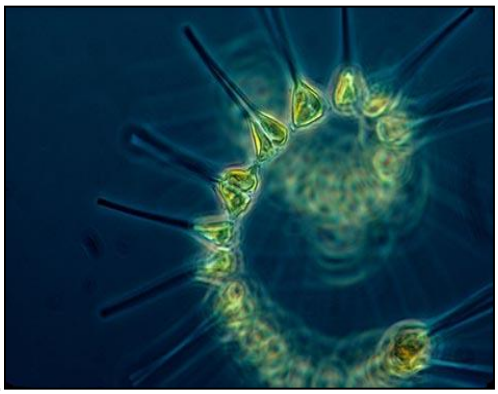
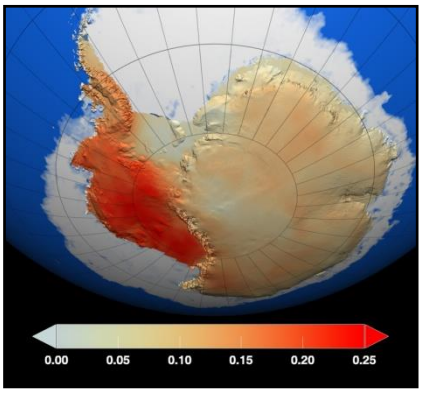
A typical season in Ryder Bay, West Antarctic Peninsula

Photo: Matthew von Tersch



Chlorophyll a



Temperature

Sea Ice

Postgraduate Certificate in Antarctic Studies 09/10

Jasmine Hodgson

Abstract

The purpose of this report is to describe an average season (in terms of sea ice, temperature and chlorophyll a levels) in Ryder Bay, near the Rothera research station on the West Antarctic Peninsula.

The data has been collected by a long term ecological research project called RaTS which has been in operation since 1997.

This data shows there is very strong seasonality in terms of all three parameters. On average, solid sea ice can be present for approximately 5 months and while the sea ice is 'fast' there is no chlorophyll growth.

As the warmer waters begin to break up the ice, chlorophyll growth increases dramatically. This pattern is repeated throughout 11 years of data.

The duration and intensity of each season is variable year to year, and is influenced by factors outside the scope of this report. However the trend is for shorter sea ice seasons, longer chlorophyll a seasons and little significant change in sea water temperature.

Contents

Introduction

RaTS – Rothera Oceanographic and Biological Time Series

The British Antarctic Survey started the Rothera Oceanographic and Biological Time Series in 1997. The purpose of the project is to make frequent, continuous and long term observations of the physical and biological marine environment, their change over time and their relationship with the atmosphere and cryosphere.

This includes documenting the seasonal pattern of sea ice, temperature, salinity, chlorophyll, pH, Nitrogen, Phosphorus and Silicon; analysing seasonal changes in these variables, especially in relation to the El Nino Southern Oscillation and the Southern Annular Mode; relating changes in the feeding habits of benthic suspension feeders to changes in the environment; and documenting the changes in the reproductive habits of selected marine invertebrates to determine if they also are related to changes in the physical environment. (RaTS website)

The RaTS research project is located on a small bay close to Rothera called Ryder Bay.

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Figure 1: West Antarctic Peninsula Location of Rothera Research Station on Adelaide Island, West Antarctic Peninsula. Picture: Wikipedia

It is important to collect long term biological data in order to understand natural variability in the environment. The Southern Ocean food web is so complex that the number of interactions between species and changes in physical environmental variables can mean that predictions based on narrowly focussed, short term studies are likely to be misleading (Clarke, A; 2007). With long term records it is possible to isolate the long and short period natural cycles, which then makes it possible to identify changes brought about by human activities.

The purpose of this report is to look at data from the last 10 years and attempt to describe a typical season in Ryder Bay with regards to sea ice extent, chlorophyll concentration and sea water temperature. (The word season is used here to describe the yearly peak of the variable).

The data can also be used to look at year on year variation which includes timing, the length of the season and its intensity. Lastly this report will also look at any correlation between these variables.

Methods

The data has been provided by Andrew Clarke and Helen Peat of the British Antarctic Survey.

The methods of collection at the RaTS station are described below.

When weather and ice permit, the RaTS base is occupied every five days in summer and weekly in winter.

Potential temperature of sea water
From 1997 to 2008 temperature values were measured at 15 m using 3 digital reversing thermometers, and from these an average temperature was obtained. From 2007 a conductivity-temperature-depth cast was also used to measure temperature and with this overlap it was determined that there was a good correlation between them and from Feb 2008 only the CTD measurements are being recorded. (Peat, H, BAS)
For the purpose of this report these two data sets were combined into one. For the overlapping period Feb 07 to Feb 08, the value used was an average of the two.

Chlorophyll a
A water bottle sample from 15m was collected and the total amount of chlorophyll a was analysed. A sample at 15m deep is considered best as this is the depth of the chlorophyll maximum most years. (Clarke, A; 2008)

Sea Ice
Each day at the RaTS station a researcher observes the ice in Ryder bay and estimates the percent of the bay which is covered. Also recorded is the type of ice present and this falls into one of five categories – Negligible or no ice, Grease (very thin film) ice, Pancake (thin) ice, Fast (solid) ice or Brash (broken up) ice. (Clarke, A; VC)

Two significant periods without data were June to December 2000 when unfavourable sea ice prevented access to any RaTS stations, and from 21 Sep 2001 to 1 Dec 2001 when the Rothera laboratory was lost to fire. There was also a small gap in late 2004/2005, when sea ice again prevented sampling for 4 weeks. (Clarke, A; 2008)

Results

Overview of relationship between sea ice, temperature and chlorophyll

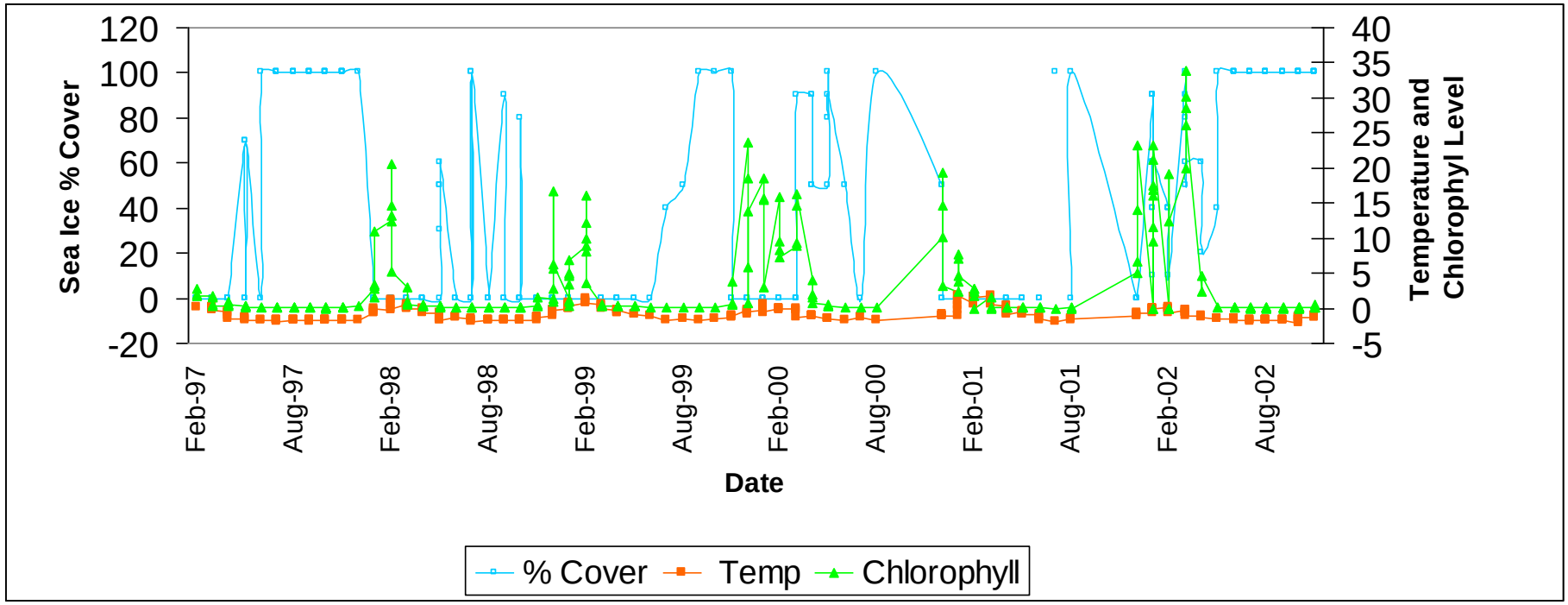


Figure 2: Period from 1997-2002.

As expected, there is a strong seasonal trend for each variable. Sea ice peaks around August each year, with chlorophyll and temperature peaking around January/February. This pattern is consistent, however the intensity and duration of the peaks changes each year.

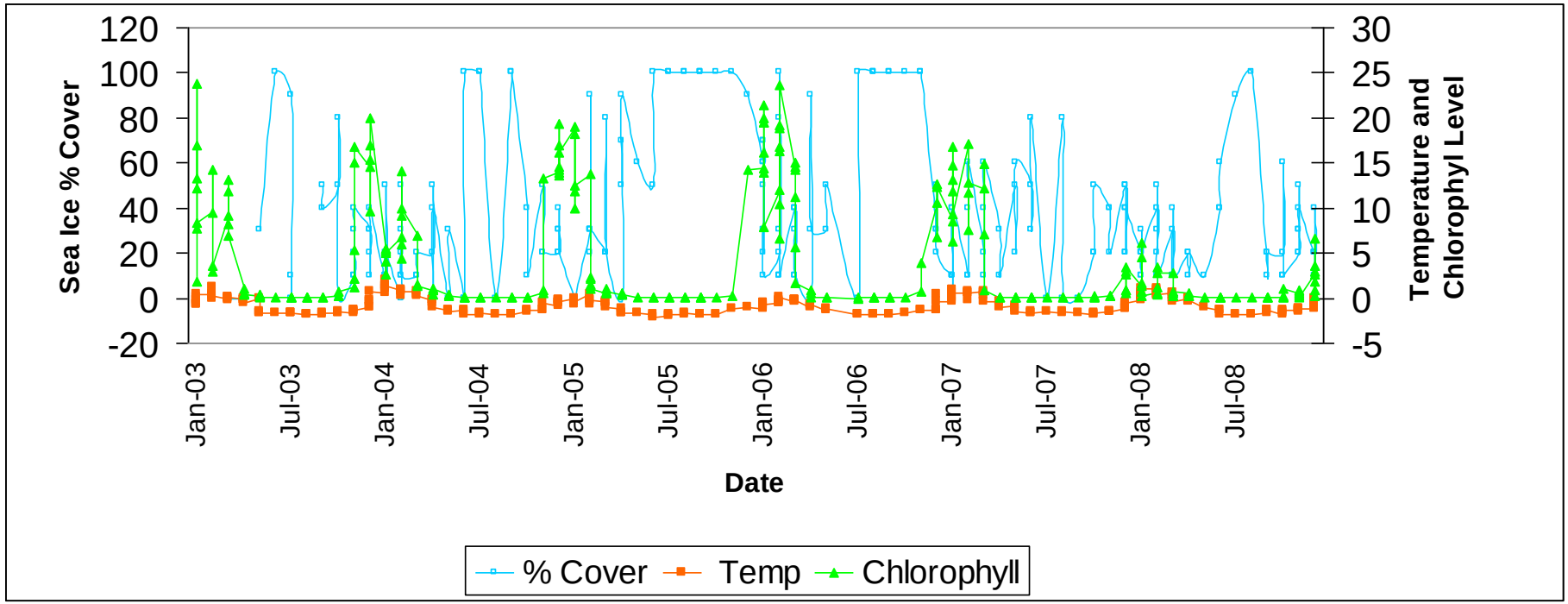


Figure 3: Period from 2003-2008.

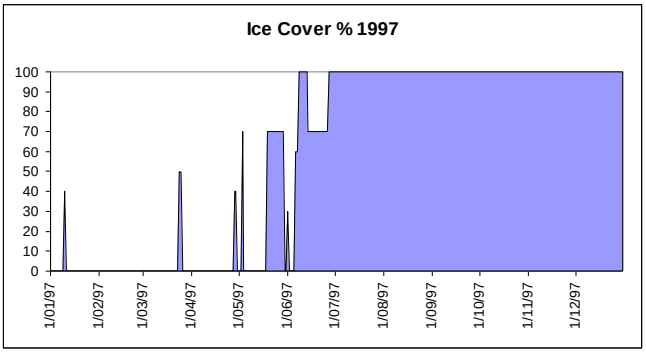
As with the graph on the previous page, the years 2003-2008 also show the same seasonal pattern of sea ice peaks in July/August and temperature/chlorophyll a peaks in January/February, however there is a lot more variation in these years.

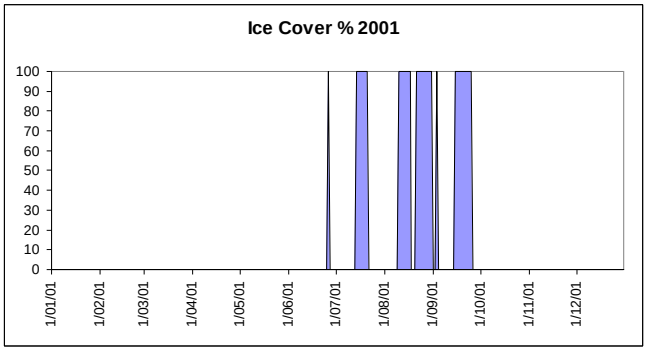
It should be noted that sea ice data has only been plotted for the days which also have chlorophyll and temperature data. This has resulted in some years appearing to have had little sea ice cover when in fact there was just lack of correlating data over winter.

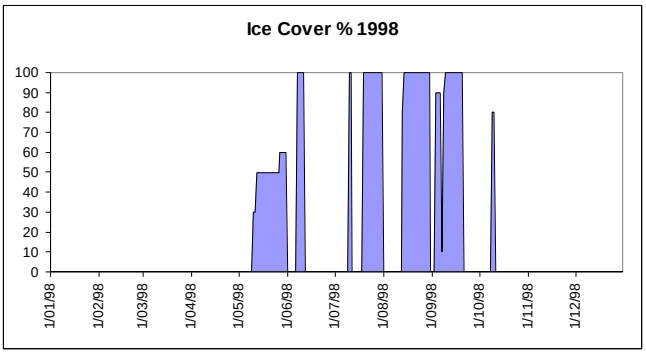
The below graphs are a better indicator of duration and intensity of seasonal sea ice.

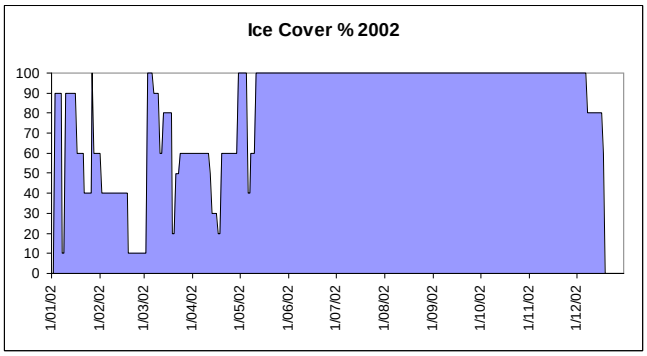
Yearly Sea Ice Cover (%)

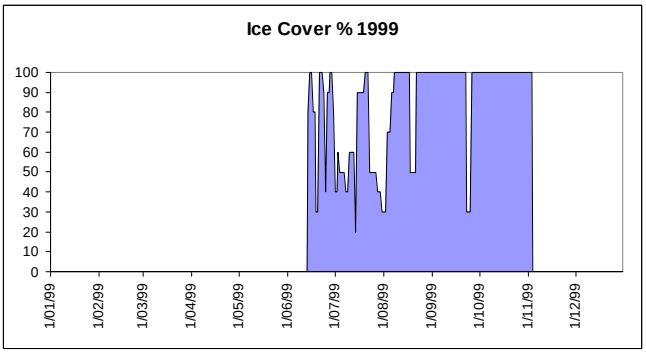
Measured as a percentage of the total area of Ryder Bay covered in any type of ice

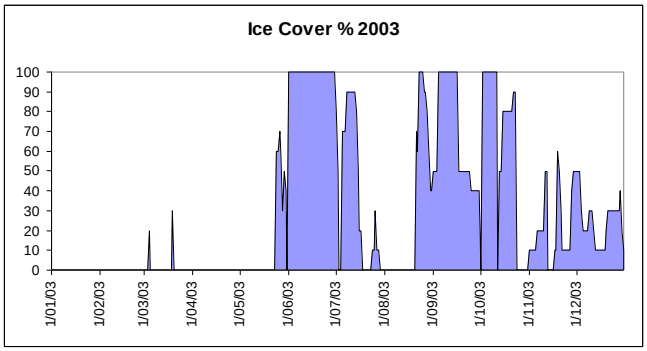


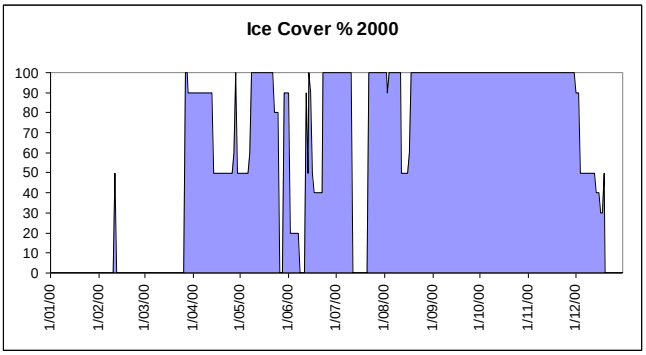


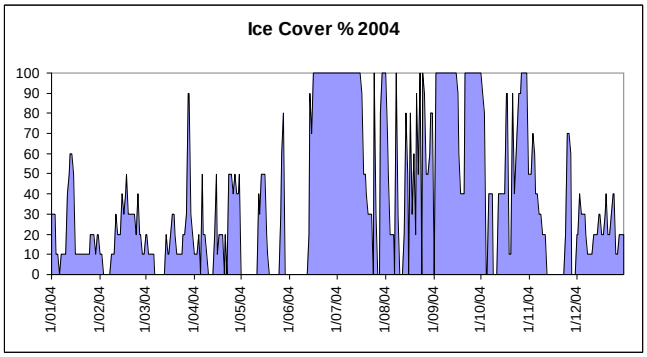


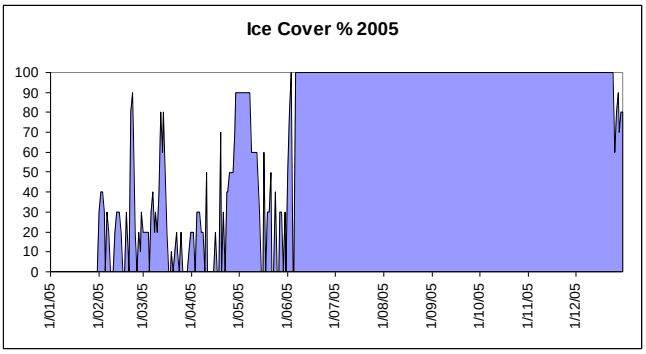








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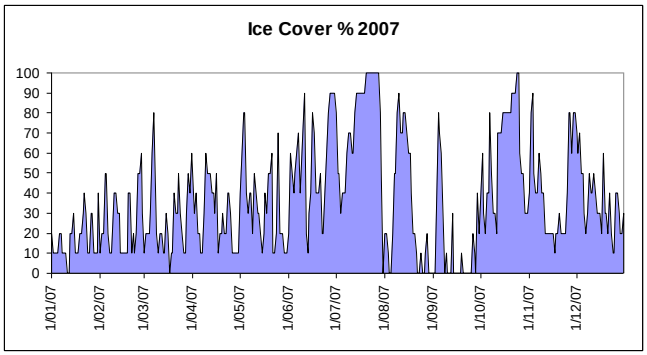
Ice Cover % 2007
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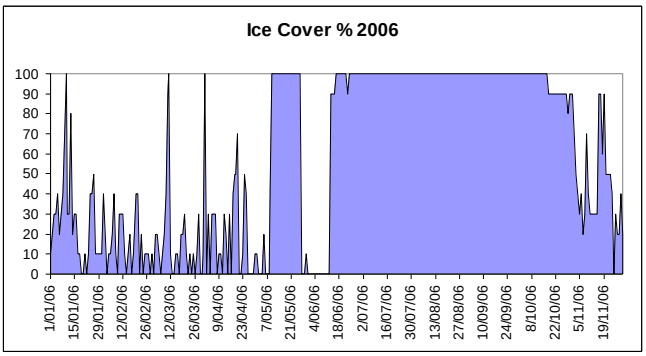
Ice Cover % 2006
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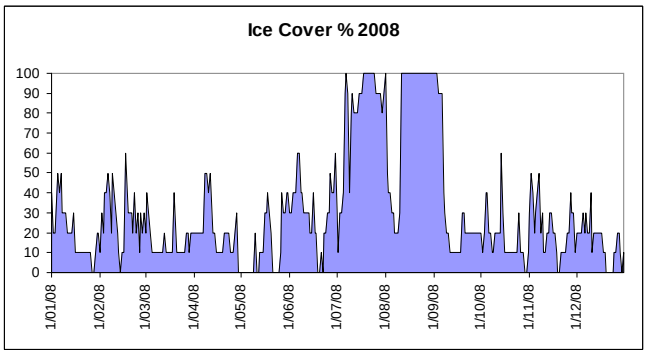
Ice Cover % 2008
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Relationship between Ice Type and Chlorophyll/Temperature

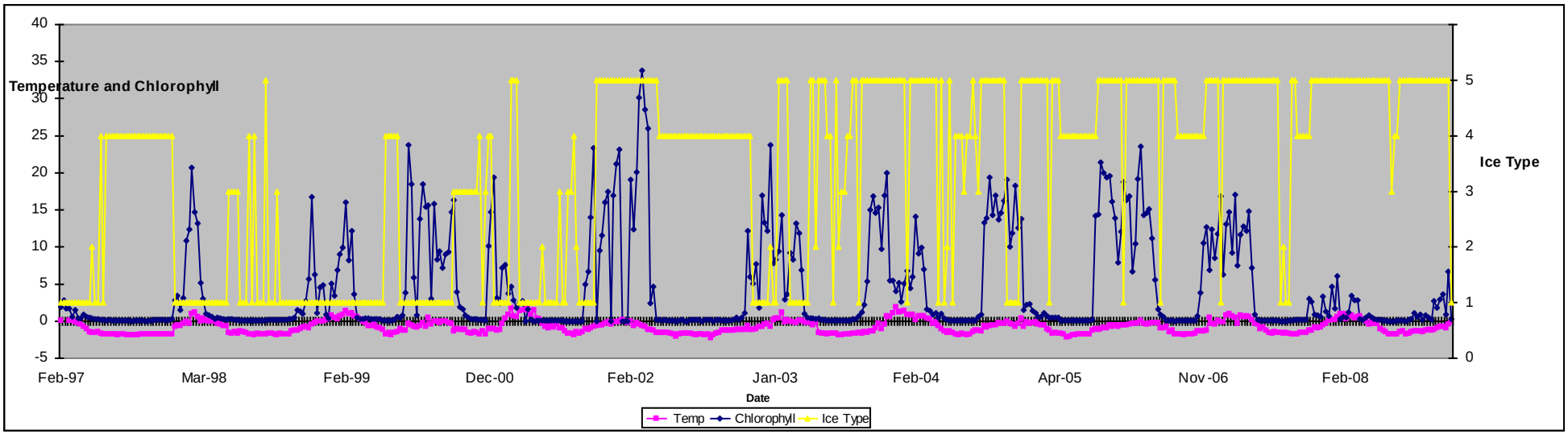

Figure 4: Ice Type vs Chlorophyll/Temperature. Ice Type Variables: 1 – negligible/zero ice, 2 – very thin grease ice, 3 – thin pancake ice, 4 – solid, fast ice, 5 – broken up, brash ice.

As seen in the figure, when the ice is type 4 (fast ice) there is very little chlorophyll measured. It is only when the ice has broken up and becomes 'brash ice', type 5, that the chlorophyll growth increases dramatically.

Relationship between Temperature and Chlorophyll a concentrations

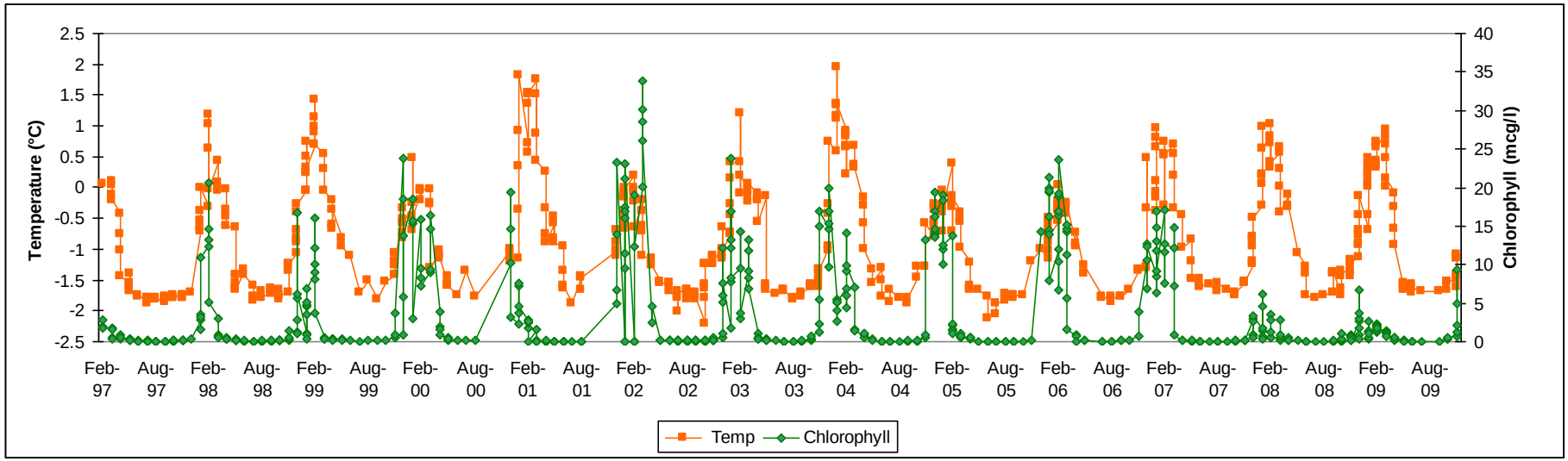

Figure 5: Temperature vs Chlorophyll concentrations.

It can be seen how an increase in temperature corresponds to an increase in chlorophyll concentrations.
It is interesting to note that higher temperatures do not result in more chlorophyll. This is an area which would be beneficial to explore further.

Seasonal Results

Chlorophyll

Below I have estimated the start and end dates of the chlorophyll season. I did this by recording the point where each seasonal trend on the graph started and ended.
The chlorophyll bloom in Marguerite Bay occurs in summer approximately from November to February. From these results the length of the season can vary from 90 to 183 days, and the intensity ranges from 6 to 23 mcg/l.

Year	Start	Start Date	Max	MaxDate	End	End Date	Min	Min Date	Length of Season (days)
1997-1998	0.30	5-Dec-97	20.66	9-Feb-98	0.96	15-Mar-98	0.06	27-Jun-98	100
1998-1999	1.48	25-Nov-98	16.70	28-Dec-98	0.44	5-Mar-99	0.09	1-Jul-99	100
1999-2000	0.82	15-Nov-99	23.71	6-Dec-99	0.82	26-Apr-00	0.11	1-Aug-00	162
2000-2001	10.14*	7-Dec-00*	19.41	21-Dec-00	1.58	6-Mar-01	0.00	15-Jul-01	90*
2001-2002	5.00*	5-Dec-01*	33.77	15-Mar-02	0.18	7-May-02	0.00	15-Sep-02	153*
2002-2003	1.07	9-Dec-02	23.77	20-Jan-03	1.01	1-Apr-03	0.04	20-Jul-03	113
2003-2004	0.72	27-Oct-03	19.97	29-Dec-03	1.02	28-Apr-04	0.04	6-Jul-04	183
2004-2005	0.54	1-Nov-04	19.39	5-Dec-04	1.08	14-Mar-05	0.05	25-Jul-05	133
2005-2006	0.20	1-Nov-05	23.57	27-Feb-06	0.64	10-Apr-06	0.00	5-Jul-06	160
2006-2007	0.68	10-Nov-06	17.08	8-Feb-07	0.93	31-Mar-07	0.02	9-Aug-07	142
2007-2008	0.19	19-Nov-07	6.10	22-Jan-08	0.80	26-Mar-08	0.02	11-Jul-08	127
Averages	**1.92**	**19-Nov-02**	**20.38**	**17-Jan-03**	**0.86**	**1-Apr-03**	**0.04**	**21-Jul-03**	**133**

*these results are not as accurate as other years because there is a lack of data for this period.

Temperature

Again, the season was measured by recording the start and end points of each seasonal trend, and also recording the maximum temperature in summer and the minimum temperature in winter.

The length of the summer season with regard to water temperature ranges from 160 to 235 days. The temperatures reach maximums of 1.9 °C. Obviously the minimum temperature shouldn't be below -1.89°C as this is the freezing point of water.

Season	Start Temp	Start Date	Max Temp	Max Date	End Temp	End Date	Length of Season
	(°C)		(°C)		(°C)		(days)
1997-1998	-1.69	5-Dec-97	1.17	17-Feb-98	-1.65	10-May-98	160
1998-1999	-1.35	11-Nov-98	1.41	10-Feb-99	-1.70	1-Jul-99	235
1999-2000	-1.06	10-Nov-99	1.41	19-Jan-00	-1.70	2-May-00	177
2000-2001	-1.02	7-Dec-00	1.81	25-Jan-01	-0.96	4-Jun-01	183
2001-2002	-1.03	5-Dec-01	0.18	2-Feb-02	-1.10	28-Mar-02	118
2002-2003	-0.65	12-Dec-02	1.19	10-Feb-03	-1.57	8-May-03	151
2003-2004	-1.32	28-Nov-03	1.93	17-Jan-04	-1.54	26-May-04	183
2004-2005	-1.28	20-Oct-04	0.39	1-Feb-05	-1.67	19-Apr-05	185
2005-2006	-1.20	1-Nov-05	0.04	27-Feb-06	-1.25	25-May-06	209
2006-2007	-1.28	12-Dec-06	0.96	25-Jan-07	-1.19	14-May-07	157
2007-2008	-1.19	7-Dec-07	1.01	4-Feb-08	-1.28	3-Jun-08	181
Average	**-1.19**	**24-Nov-02**	**1.05**	**3-Feb-03**	**-1.42**	**16-May-03**	**176**

Ice Cover

This data shows the dates at which ice cover had become solid fast ice and the coverage had reached 100%. For each year I recorded the first day this occurred and the last day of the year that this occurred. The time between these dates is the length of the season in terms of sea ice coverage.

Year	**Start Date**	Day of Year	**End Date**	Day of Year	**Length of Season**
					(days)
1997	5-Jun-97	156	31-Dec-97	365	209
1998	7-Jun-98	158	20-Sep-98	263	105
1999	20-Jul-99	201	2-Nov-99	306	105
2000	14-Jun-00	166	30-Nov-00	335	169
2001	26-Jun-01	177	25-Sep-01	268	91
2002	11-May-02	131	7-Dec-02	341	210
2003	1-Jun-03	152	11-Oct-03	284	132
2004	16-Jun-04	168	30-Oct-04	304	136
2005	6-Jun-05	157	25-Dec-05	359	202
2006	17-Jun-06	168	17-Nov-06	321	153
2007	20-Jul-07	201	25-Oct-07	298	97
2008	18-Jul-08	200	3-Sep-08	247	47
Average	**19-Jun**	170	**4-Nov**	308	**138**

Yearly Trends

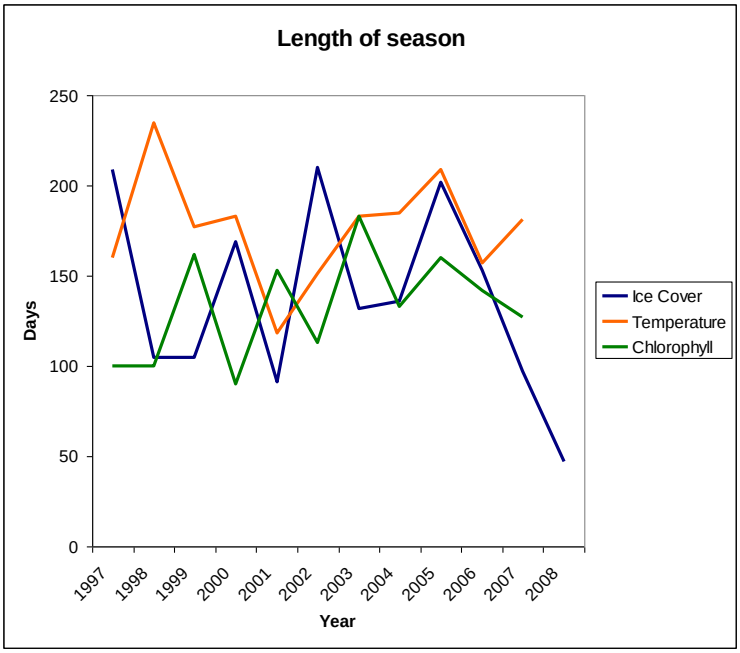

Figure 6: Season length for each parameter over 11 years.

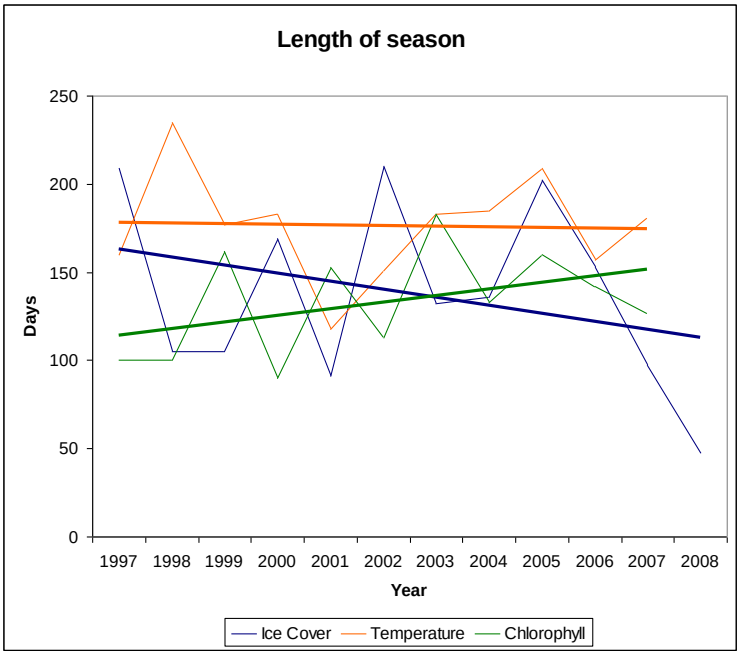

Figure 7: Trend lines. The duration of each season over 11 years.

As shows from the graph above, the period in which Marguerite Bay is completely covered in ice is decreasing over time.
Periods of high temperature are also getting shorter; however the length of time of high chlorophyll a concentrations is increasing.

Discussion and Conclusions

Description of a season in Ryder Bay, Antarctica.

The season starts around June when the bay becomes completely covered in solid, fast ice. This lasts for around 4-5 months. As the area moves into summer, the waters warm and the ice breaks up, becoming 'brash' ice.

This leads to a dramatic increase in growth of chlorophyll a, due to the increased amount of sunlight now available. The start of the chlorophyll season is around November/December and there is high growth until approximately March or April.

Yearly variability

There is strong yearly variability in all three variables.

Changes in temperature have a marked effect on sea ice. The years 2001 and 2004 in particular show how there is a correlation between warmer temperatures and less sea ice cover, which is to be expected. It is unclear whether the effect on chlorophyll was significant, and this is an area for further exploration.

The length of each sea ice season also changes dramatically, but this is also influenced by factors outside the scope of this report, such as the El Nino Southern Oscillation and the Southern Annular Mode. (Stammerjohn et al, 2008).

According to this data, there is not a significant trend in season length for water temperature, however the season for high chlorophyll concentrations is getting longer and this could be related to the shorter amount of time the bay is covered in sea ice.

In conclusion, there is a lot of data in this report which would be interesting to analyse further. Outside influences can be taken into account and a more accurate

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